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W_R effects on CP angles determination at a B factory

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Abstract

The right-handed charged current gauge boson W_R can affect significantly on the determination of the CP violation angles to be measured at B factories if the right-handed current quark mixing matrix V^R is taken to a specific form to satisfy the bounds by neutral K meson systems. The W_R contribution can be sizable in B^0-$\overline{B^0}$ mixing and tree level b quark decay. The deviation of CP angles in unitarity triangle from the standard model values can be as large as $-37°$ or $+22°$ for ϕ_3 (γ), and $66° \sim 115°$ for ϕ_1 (β) and ϕ_2 (α).

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1 Introduction

One of the main purposes of the B factories which are now under construction at KEK[1] and SLAC[2] is to find a sign of new physics beyond the standard model. If a new physics significantly affects B^0-$\overline{B^0}$ mixing or CP violation in B decays[3], the angles and the sides of the so-called unitarity triangle deviate from the standard model values, and the consistency of the triangle will be lost[4]. The extensive measurements at B factories are going to fix all the sides and angles of the unitarity triangle. We can find a signal of new physics or at least constraints by over-checking the consistency of the triangle.

New physics effects are often considered to appear at loop level because the masses of most of the new particles in the models beyond the standard model are larger than the electro-weak scale of $O(M_W)$ to satisfy the bounds by the present experimental data. A heavy new particle would not be able to give a significant contribution to the tree level b quark decay. However, this is not always the case. The decay of b quark through the standard W boson exchange is suppressed by the smallness of the involving Kobayashi-Maskawa (KM) matrix[5] elements, V_{cb} and V_{ub}. A new particle can contribute significantly to tree level b decay if it has non-suppressed coupling with quarks. We consider the W_R boson in the $SU(2)_L \times SU(2)_R \times U(1)$ models[6] as an example of such a new particle in this paper.

In addition to the ordinary KM matrix there exists a flavor mixing matrix also in the coupling between right-handed quark currents and W_R boson in $SU(2)_L \times SU(2)_R \times U(1)$ models, which shall be called as V^R while the usual left-handed current KM matrix as V^L hereafter. It has been shown that the mass of W_R should be greater than 1.4 TeV to be consistent with the experimental data of K^0-$\overline{K^0}$ mixing if a model has manifest or pseudo manifest left-right symmetry, i.e. $V^L = V^R$ or $V^L = (V^R)^*$, respectively[7]. The W_R boson cannot contribute significantly to tree level b decay with such a heavy mass and V^R. But right-handed charged current interaction has not been observed yet, so the the form of V^R is not restricted to manifest or pseudo manifest type. Olness and Ebel have shown that the mass limit of W_R can be lowered to 300 GeV by assuming specific forms of V^R[8]. Langacker and Sankar have also made a detailed analysis on W_R mass limit, and come to a similar conclusion that the lower limit of W_R mass can be reduced by taking the following forms of V^R[9];

$$V_I^R = \begin{pmatrix} e^{i\omega} & 0 & 0 \\ 0 & ce^{i\xi} & se^{i\sigma} \\ 0 & se^{i\varphi} & ce^{i\chi} \end{pmatrix}, \qquad V_{II}^R = \begin{pmatrix} 0 & e^{i\omega} & 0 \\ ce^{i\xi} & 0 & se^{i\sigma} \\ se^{i\varphi} & 0 & ce^{i\chi} \end{pmatrix}, \tag{1}$$

where $s = \sin\theta$ and $c = \cos\theta$ $(0 \le \theta \le 90°)$.[4] Unitarity requires $\xi - \sigma = \varphi - \chi + \pi$. We call the former type of V^R as type I and the latter as type II in the following discussion. London and Wyler have pointed out that both types of V^R lead to sizable contributions to CP violation in K and B systems[10]. For example, the CP asymmetry in $B \to J/\Psi K_s$ decay can be significantly altered by the presence of W_R mediated $b \to c\bar{c}s$ tree decay with the V^R of type I.

The aim of this paper is to make a detailed study on the effects of W_R on the determination of the three CP angles to be measured at the B factories. In particular, we show that the measurement of the angle ϕ_3 (or γ)[5] can receive a sizable effect by W_R in the case of type II right-handed Kobayashi-Maskawa matrix, V^R, even if W_R is as heavy as about 1 TeV. The CP angle ϕ_3 (or γ) was considered to be measured on the B_s decay, $B_s \to \rho K_S$ in many of the previous papers. But the experiments at B factories at the first stage will be made on $\Upsilon(4S)$ which can not decay into B_s. The measurement of the angle ϕ_3 (or γ) is to be made on $B \to DK$ decays[3, 12]. Our analysis on the angle ϕ_3 (or γ) is based on this method.

The rest of this paper is organized as follows: In section 2 we give constraints of the parameters from K and B systems. In section 3 we estimate the W_R contribution to the CP violation angles in decays of b quark. The final section is devoted to summary and discussion.

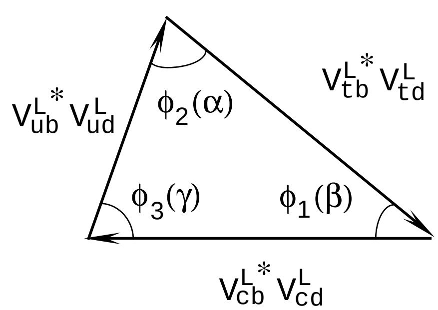

Figure 1: Unitarity triangle

[4] The elements 0 in these matrices may be $O(10^{-2})$. We take them 0 for the simplicity of discussion.

[5] There are two notations for the angles of unitarity triangle. One given in ref.[1] and the another in ref.[11]. We take the notation of ref.[1] as β is used to express another quantity here.

2 Constraints from K and B systems

2.1 K^0-$\overline{K^0}$ mixing

The box diagram with one W_L (standard W boson) and one W_R can give the major contribution to K^0-$\overline{K^0}$ mixing in $SU(2)_L \times SU(2)_R \times U(1)$ models[7, 13]:

$$\mathcal{H}_{LR}^{eff} = \sum_{i,j=u}^{t} \frac{2G_F^2 M_W^2}{\pi^2} \beta_g V_{id}^{L*} V_{is}^{R} V_{jd}^{R*} V_{js}^{L} J(x_i, x_j, \beta)\, \overline{d_R} s_L \overline{d_L} s_R + (\text{h.c.}), \quad (2)$$

where β is the square of the ratio of W_L mass (M_L) to W_R mass (M_R), M_L^2/M_R^2, $\beta_g = (g_R/g_L)^2 \beta$ and $x_i = m_i^2/M_L^2$. The loop function is defined as

$$J(x, y, \beta) \equiv \sqrt{xy}[(\eta^{(1)} + \eta^{(2)} \frac{xy\beta}{4}) J_1(x, y, \beta) - \frac{1}{4}(\eta^{(3)} + \eta^{(4)}\beta) J_2(x, y, \beta)], \quad (3)$$

with

$$\begin{aligned} J_1(x, y, \beta) &= \frac{x \ln x}{(1-x)(1-x\beta)(x-y)} + (x \leftrightarrow y) - \frac{\beta \ln \beta}{(1-\beta)(1-x\beta)(1-y\beta)} , \\ J_2(x, y, \beta) &= \frac{x^2 \ln x}{(1-x)(1-x\beta)(x-y)} + (x \leftrightarrow y) - \frac{\ln \beta}{(1-\beta)(1-x\beta)(1-y\beta)} , \end{aligned}$$

where $\eta^{(1)-(4)}$ are QCD corrections. The box diagram with two W_R cannot contribute to K^0-$\overline{K^0}$ mixing as long as we take V^R to be in the forms of eq.(1). We have neglected W_L-W_R mixing as it is highly suppressed by the experimental data[9]. The real part of the matrix element $\langle K^0 | \mathcal{H}_{LR}^{eff} | \overline{K^0} \rangle$ contributes to ΔM_K, while the imaginary part to the CP violation parameter ϵ in K decay. The constraint by ΔM_K [8, 9] is satisfied for $M_R > 0.52$ TeV which we take as the limit from direct search[11] under the assumption that right-handed neutrino ν_R does not affect the b semi-leptonic decay. The constraint from ϵ is much severe. W_R has to be as heavy as about 5 TeV or more unless the parameters in V^R are tuned[10] . By using the Wolfenstein parameterization[15] of KM matrix V^L,

$$V^L = \begin{pmatrix} 1 - \frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1 - \frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1 - \rho - i\eta) & -A\lambda^2 & 1 \end{pmatrix}, \quad (4)$$

we find that the contribution to ϵ has the following combinations of quark mixing matrix elements:

type I (uc contribution): $\lambda^2 c \sin(\omega - \xi)$

type I (ut contribution): $A\lambda^4 s[(1-\rho)\sin(\varphi-\omega)+\eta\cos(\varphi-\omega)]$

type II (uc contribution): $(1-\frac{\lambda^2}{2})^2 c\sin(\omega-\xi)$

type II (ut contribution): $-A\lambda^2(1-\frac{\lambda^2}{2})s\sin(\omega-\varphi)$

To suppress large contribution to ϵ from W_L-W_R box diagram we take the following solutions for V^R;

type I

$$\sin(\omega-\xi)=0 \text{ and } \tan(\omega-\varphi)=\frac{\eta}{1-\rho}, \tag{5}$$

type II

$$c=0 \text{ and } \sin(\omega-\varphi)=0. \tag{6}$$

There are other solutions to suppress ϵ. We take these since they give most significant effects on CP violation in B decay by W_R.

2.2 B semi-leptonic decay

B semi-leptonic decays gives the constraint on the ordinary KM matrix elements, $|V_{cb}|$ and $|V_{ub}|$. It is independent of the W_R effects as far as the right handed neutrinos are heavier than b quark, which we take as a reasonable assumption. Then B semi-leptonic decays constrain only the elements of V^L.

2.3 B^0-$\overline{B^0}$ mixing

Let us write the contribution to B^0-$\overline{B^0}$ mixing matrix elements as

$$M_{12}^B = M_{12}^{SM}[1+d_{LR}+d_{RR}], \tag{7}$$

where d_{LR} and d_{RR} are the contributions by the box diagrams with one W_R and those with two W_R, respectively. The contribution by W_R depends on which of V^R in type I and II we take. In the following discussions we take the gauge coupling of $SU(2)_L$ (g_L) and that of $SU(2)_R$ (g_R) equal for the simplicity of the following arguments. W_L-W_R mixing is neglected.

2.3.1 Type I

The contribution d_{RR} vanishes because $V^R_{Iib}V^{R*}_{Iid}=0$ for any $i=u,c,t$. By replacing s with b in eq.(2) we can calculate d_{LR}, which is written as

$$d_{LR}=\frac{V^L_{ub}V^{L*}_{cd}se^{i(\sigma-\omega)}}{(V^L_{tb}V^{L*}_{td})^2}r_{uc}+\frac{V^L_{ub}V^{L*}_{td}ce^{i(\chi-\omega)}}{(V^L_{tb}V^{L*}_{td})^2}r_{ut}\ , \tag{8}$$

where r_{uc} (r_{ut}) are the ratios of the W_R contribution to the standard model one of u, c (u, t) quarks up to quark mixing matrix elements. We find $|r_{uc}|$ is $O(10^{-6})$ or less and $|r_{ut}|$ is $O(10^{-5})$ or less for $M(W_R) > 0.5$ TeV, while the absolute magnitudes of the coefficients of r_{uc} and r_{ut} in eq.(8) are $O(10)$ and $O(1)$, respectively. (Note that $|V^L_{td}|$ should be $O(\lambda^3)$ to realize the experimental value of ϵ in K system.) Therefore, we can neglect the W_R contribution to B^0-$\overline{B^0}$ mixing in the case of type I.

2.3.2 Type II

We take the solution given in eq.(6) to suppress the large contribution to ϵ. Then the contribution d_{RR} vanishes. The contribution d_{LR} is given in the Wolfenstein parameterization of V^L as,

$$d_{LR} = \frac{V^L_{tb} V^{L*}_{cd} e^{i(\sigma-\varphi)}}{(V^L_{tb} V^{L*}_{td})^2} r_{ct} = -\frac{e^{i(\sigma-\varphi-\phi_{SM})}}{A^2\lambda^5[(1-\rho)^2+\eta^2]} r_{ct}, \qquad (9)$$

where $\phi_{SM} = \arg(M^{SM}_{12})$. The ratio r_{ct} is $O(10^{-3})$ as shown in Fig.2.

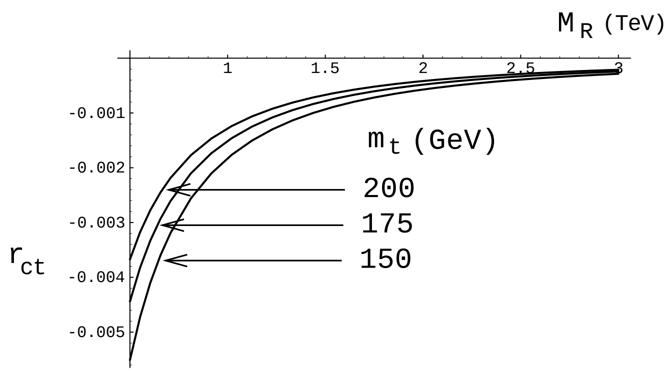

Figure 2: The ratio of W_R contribution to W_L contribution up to quark mixing matrix elements.

We have used $\eta^{(1)} = 1.1$, $\eta^{(2)} = 0.26$, $\eta^{(3)} = 1.1$ $\eta^{(4)} = 1.0$ for W_R contribution[13], $\eta_{tt} = 0.8$ for W_L contribution[14] as the values of QCD corrections, $m_c = 1.5$ GeV and $m_b = 4.6$ GeV in calculating r_{ct}.The factor $1/(A^2\lambda^5[(1-\rho)^2+\eta^2])$ is $O(10^3)$. The experimental value of B^0-$\overline{B^0}$ mixing can be realized depending on the parameters in V^L and V^R. We fix $\lambda = 0.22$, $A = 0.8$, and investigate the following two cases;

$$r_B \equiv \sqrt{(1-\rho)^2+\eta^2} = \begin{cases} 1.3 & : \text{case (a)} \\ 1.0 & : \text{case (b)} \end{cases} . \qquad (10)$$

The above two cases are shown in Fig.3 with the allowed regions by ϵ in K decay and B semi-leptonic decay, where we take $m_t = 150 \sim 200$ GeV and $B_K = 0.6 \sim 1.0$. We find that the allowed region of ϕ_1 (β) is $7^\circ \sim 15^\circ$ for case (a), $13^\circ \sim 25^\circ$ for case (b). The phase of M_{12}^{SM}, ϕ_{SM}, is given by $\arg[(V_{tb}^L V_{td}^{L*})^2] = 2\phi_1$ in the phase convention of V^L in eq.(4).

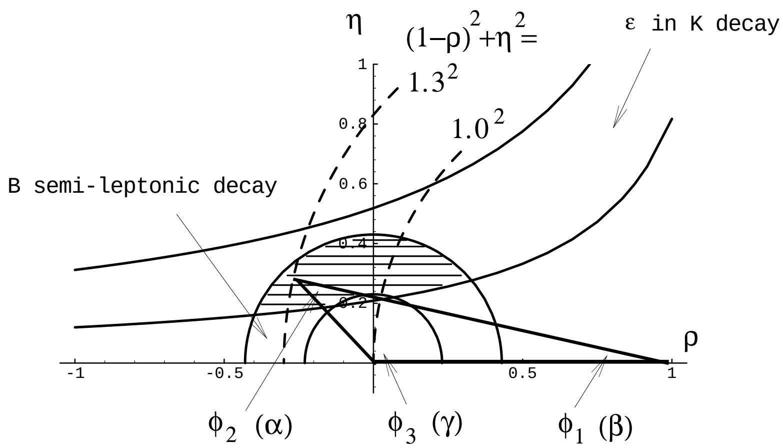

Figure 3: Allowed region in ρ-η plane consistent with ϵ in K decay and B semi-leptonic decay. The dashed lines shows the curves $(1-\rho)^2 + \eta^2 = 1.3^2$ and 1.0^2. The three angles of unitarity triangle are also shown.

The ratio of the experimental data, $M_{12}^{B(exp)}$, for $\Delta M_B = 0.462 \pm 0.026\text{ps}^{-1}$ [16] to the standard model contribution is given for $m_t = 150, 175, 200$ GeV, $r_B = 1.3, 1.0$, $f_B = 140 \sim 200$ MeV and $B_B = 0.7 \sim 1.1$ in Table 1:

r_B	$m_t = 150$ (GeV)	175	200
1.3	$0.42 \sim 1.5$	$0.33 \sim 1.2$	$0.27 \sim 0.96$
1.0	$0.70 \sim 2.5$	$0.55 \sim 2.0$	$0.45 \sim 1.6$

Table 1 : $|M_{12}^{B(exp)}/M_{12}^{SM}|$

The equations (7) and (9) give

$$\left|\frac{M_{12}^B}{M_{12}^{SM}}\right| = \left|1 - e^{i(\sigma-\varphi-\phi_{SM})}\frac{r_{ct}}{A^2\lambda^5[(1-\rho)^2+\eta^2]}\right|. \tag{11}$$

We require the right-hand side of eq.(11) should be within the values give in Table 1. Taking as an example $m_t = 175$ GeV, $r_B = 1.3$ and $M_R = 1.2$ TeV, we obtain the allowed region of phases in V^R as seen in Fig.4. It gives the

range of the angle $\sigma - \varphi - \phi_{SM} = 154^\circ \sim 206^\circ$, which gives the deviation of the $\arg M_{12}$ from the standard model value, $\delta\phi_{SM} = 131^\circ \sim 229^\circ$.

There should be overlap between the shaded region and the circle whose center is $(1, 0)$ in Fig.4 for the consistency with the experimental value of ΔM_B. The radius of the circle depends on W_R mass, so that we can derive the bound of M_R, which is shown in Table 2.

r_B	$m_t = 150$ (GeV)	175	200
1.3	> 1.1	> 1.1	$11 > M_R > 1.0$
1.0	> 1.3	> 1.2	> 1.2

Table 2 : W_R mass bound (TeV)

Note that we need a new physics contribution to cancel too large W_L contribution in the case of $m_t = 200$ GeV and $r_B = 1.3$.

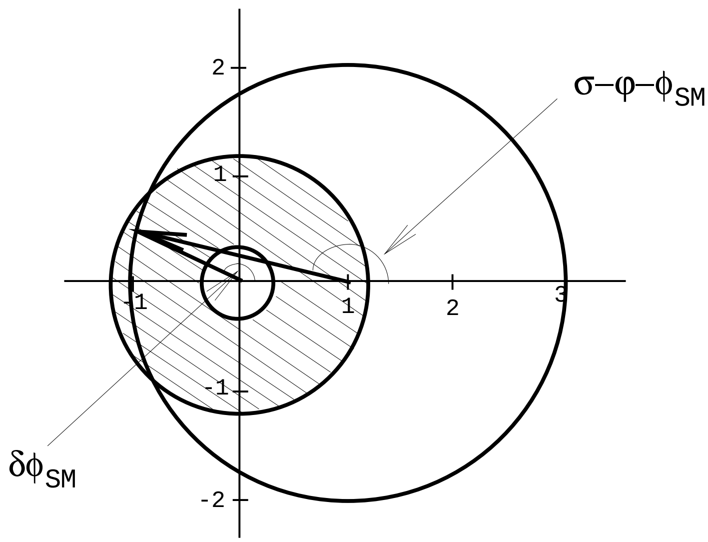

Figure 4: Allowed region of d_{LR}. The shadowed region corresponds to the left-hand side of eq.(11) with the value given in Table 1. The vector with arrow expresses the second term in the right-hand side of eq.(11).

3 Effects on CP angles

3.1 ϕ_1

The CP angle ϕ_1 (β) is measured in the decay, $B^0(\overline{B^0}) \to J/\Psi K_S$. It is $b(\bar{b}) \to c\bar{c}s(\bar{s})$ decay in the quark picture. The involving quark mixing matrix elements are V_{cb} and V_{cs}. The experiments fix the angle ϕ_1^{exp} which coincides

with the angle ϕ_1 of the unitarity triangle in the case of standard model. It is related to M_{12}^B and the decay amplitudes as follows:

$$\sin 2\phi_1^{exp} = -\mathrm{Im}\left[\frac{|M_{12}^B|}{M_{12}^B}\frac{A(\overline{B^0}\to J/\Psi K_S)}{A(B^0\to J/\Psi K_S)}\right]. \tag{12}$$

Penguin diagram also contributes to this decay in addition to the tree graphs. The phase of W_L (W_R) penguin amplitude has the same phase with W_L (W_R) tree amplitudes. In the case of V^R of type I the ratio of W_L contribution to W_R contribution in decay amplitudes is given as

$$\begin{aligned} W_L \text{ contribution} : W_R \text{ contribution} &= \frac{g_L^2}{M_L^2}V_{cb}^L V_{cs}^{L*}(1+P) : \frac{g_R^2}{M_R^2}V_{cb}^R V_{cs}^{R*}(1+P') \\ &= 1 : \beta_g \frac{cse^{i(\sigma-\xi)}}{A\lambda^2}\frac{1+P'}{1+P}, \end{aligned} \tag{13}$$

where P (P') is W_L (W_R) penguin contribution. We have $P \sim P' \propto \alpha_S \ln(m_t^2/m_c^2)$ in the first approximation, so that we take $(1+P')/(1+P) = 1$. By putting $\lambda = 0.22$, $A = 0.8$, $c = s = 1/\sqrt{2}$ and $M_R > 0.52$ TeV we find W_R contribution is 30 % or less of the W_L contribution, which corresponds to 18° or less deviation of ϕ_1^{exp} from ϕ_1. Note that the constraints given in the previous section do not affect this conclusion except for W_R mass bound because W_R does not contribute significantly to B^0-$\overline{B^0}$ mixing and the solution (5) to suppress ϵ is independent of $\sigma - \xi$.

In the case of V^R of type II there are no tree nor penguin contributions by W_R in this decay mode. But there can be significant contribution to B^0-$\overline{B^0}$ mixing which gives rise to deviation of ϕ_1^{exp} from the standard model value, $\delta\phi_1 = \delta\phi_{SM}/2 = 66^\circ \sim 115^\circ$, as discussed in sec.2.3.2.

3.2 ϕ_2

Measurement of the asymmetry in $B^0, \overline{B^0} \to \pi\pi$ gives the angle ϕ_2^{exp}. The involving quark mixing matrix elements are V_{ub} and V_{ud}. No tree nor penguin W_R contributions exist in this decay mode in both cases of type I and type II. There is no significant contribution to B^0-$\overline{B^0}$ mixing in the case of type I, so that ϕ_2^{exp} coincides with ϕ_2. But large contribution is possible in type II case, which leads to large deviation between ϕ_2^{exp} and ϕ_2 just as estimated in the preceding subsection for ϕ_1.

3.3 ϕ_3

The CP angle ϕ_3^{exp} is fixed through the decays of B mesons into neutral D (D^0, $\overline{D^0}$, CP eigenstates of D) and K. The involving quark mixing matrix

elements are $V_{cb}V_{us}^*$, $V_{ub}V_{cs}^*$ and their complex conjugates. Penguin contribution is absent in this decay mode. There is no W_R contribution in the case of type I, while there is a tree level contribution in the case of type II.

$$\begin{aligned} W_L \text{ contribution} : W_R \text{ contribution} &= \frac{g_L^2}{M_L^2} V_{cb}^L V_{us}^{L*} : \frac{g_R^2}{M_R^2} V_{cb}^R V_{us}^{R*} \\ &= 1 : \beta_g \frac{e^{i(\sigma-\omega)}}{A\lambda^3}. \end{aligned} \tag{14}$$

To estimate the deviation $\delta\phi_3 \equiv \phi_3^{exp} - \phi_3$ we define $\beta_g/(A\lambda^3) \equiv r_3$ and replace $V_{cb}^L V_{us}^{L*}$ by $V_{cb}^L V_{us}^{L*}[1 + r_3 e^{i(\sigma-\omega)}] = V_{cb}^L V_{us}^{L*}[1 \pm r_3 e^{i(\sigma-\varphi)}]$, where eq.(6) has been used. The discussion at sec.2.3.2 gives $\sigma - \varphi - \phi_{SM} = 154° \sim 206°$ and $\phi_{SM} = 2\phi_1 = 14° \sim 30°$ for $m_t = 175$ GeV, $r_B = 1.3$ and $M_R = 1.2$ TeV. Then $\sigma - \varphi = 168° \sim 236°$, and we find $\delta\phi_3 = -32° \sim +19°$ from Fig.5. We have analyzed $\delta\phi_3$ for other set of parameters. The results are given in Table 3.

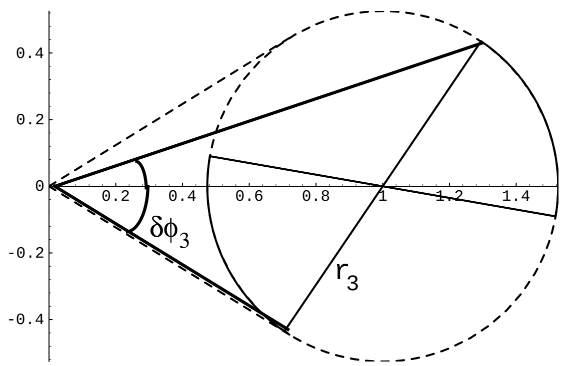

Figure 5: $\delta\phi_3$ for $r_B = 1.3$ and $M_R = 1.2$ TeV in the case of type II. The solid parts of the circle express $r_3 e^{i(\sigma-\varphi)}$ with $\sigma - \varphi = 168° \sim 236°$ (mod 180°).

r_B	$m_t = 150$ (GeV)	175	200
1.3	$-32° \sim +17°$ $(M_R = 1.2)$ $-11° \sim +11°$ $(M_R = 2.0)$	$-32° \sim +19°$ $(M_R = 1.2)$ $-11° \sim +11°$ $(M_R = 2.0)$	$-37° \sim -12°$, $+3° \sim +14°$ $(M_R = 1.1)$ $-11° \sim +11°$ $(M_R = 2.0)$
1.0	$-23° \sim +22°$ $(M_R = 1.4)$ $-11° \sim +11°$ $(M_R = 2.0)$	$-27° \sim -10°$, $+4° \sim +19°$ $(M_R = 1.3)$ $-11° \sim +11°$ $(M_R = 2.0)$	$-27° \sim -5°$, $+2° \sim +20°$ $(M_R = 1.3)$ $-11° \sim +11°$ $(M_R = 2.0)$

Table 3 : The values of $\delta\phi_3$. The masses of W_R boson (M_R) is given in unit of TeV.

4 Summary and discussion

We have investigated the effects of W_R on CP violation in B decays. The right-handed charged current gauge boson W^R can affect significantly on the determination of the CP violation angles to be measured at B factories if the right-handed current quark mixing matrix V^R is chosen to satisfy the bounds by neutral K meson system with relatively light W_R of $M_R = 0.5 \sim 1.5$ TeV. The W_R contribution can be sizable in B^0-$\overline{B^0}$ mixing and tree level b quark decay. In the case of V^R of type I the CP angle ϕ_1 (β) can deviate from the standard model value by as large as $18°$ for $M_R = 0.52$ TeV. In the case of V^R of type II the CP angle ϕ_1 (β) and ϕ_2 (α) can deviate by $66° \sim 115°$ and ϕ_3 (γ) by $-32° \sim +19°$ for $M_R = 1.2$ TeV. These results have been obtained under specific sets of parameters for the simplicity of calculation; $A = 0.8$, $\sqrt{(1-\rho)^2+\eta^2} = 1.0, 1.3$, $B_K = 0.6 \sim 1.0$, $B_B = 0.7 \sim 1.1$, $g_L = g_R$ and neglecting W_L-W_R mixing. The values of deviation will be modified if we enlarge or restrict the region of these parameters.

One notable point of the W_R effects is the fact that the sum of the measured three CP angles does not become $180°$. It has often been pointed out that a key of new physics search in B meson system is a check of sum of three CP angles[4]. However, the sum of the angles measured on $\Upsilon(4S)$, where the CP angle ϕ_3 (γ) is fixed through $B \to DK$ decay, becomes $180°$ even with sizable new physics contributions if new physics affects on B^0-$\overline{B^0}$ mixing alone as can be seen in the definitions of the CP angles to measure. This result can be extended to 4 or more generation models, vector-quark models and so on where Kobayashi-Maskawa matrix is not necessarily unitary in the first 3×3 part[17]. $SU(2)_L \times SU(2)_R \times U(1)$ models will be one of promising candidates of new physics if sum of the three CP angles measured in coming experiments does not become $180°$.

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References

[1] *Letter of Intent for a Study of CP Violation in B Meson Decays*, KEK Report 94-2 (1994).

[2] *Letter of Intent for the Study of CP Violation and Heavy Flavor Physics at PEP II*, SLAC-443 (1994).

[3] A.B. Carter and A.I. Sanda, Phys. Rev. Lett. **45** 952 (1980), Phys. Rev. **D23** 1567 (1981);
I.I. Bigi and A.I. Sanda, Nucl. Phys. **B193** 85 (1981), Nucl. Phys. **B281** 41 (1987).

[4] For reviews see
Y. Nir, *Proc. of the Workshop on B physics at Hadron Accelerators*, eds. P. McBride and C.S. Mishra, SSCL-SR-1225, Fermilab-CONF-93/267, 185 (1993);
Y. Nir and H.R. Quinn, Ann. Rev. Nucl. Part. Sci. **42** 211 (1992).

[5] M. Kobayashi and T. Maskawa, Prog.Theor.Phys. **49**, 652 (1973).

[6] R.N. Mohapatra and J.C. Pati, Phys. Rev. **D11** 566 (1975), **D11** 2558 (1975);
G. Senjanovic and R.N. Mohapatra, Phys. Rev. **D12** 1502 (1975);
G. Senjanovic, Nucl. Phys. **B153** 334 (1979).

[7] G. Beall, M. Bander and A. Soni, Phys. Rev. Lett. **48** 848 (1982).

[8] F.I. Olness and M.E. Ebel, Phys. Rev. **D30** 1034 (1984).

[9] P. Langacker and S.U. Sankar, Phys. Rev. **D40** 1569 (1989).

[10] D. London and D. Wyler, Phys. Lett. **B232** 503 (1989).

[11] L. Montanet et.al., Phys. Rev. **D50** 1173 (1994) and 1995 off-year partical updata for 1996 edition available on the PDG WWW pages (URL:http://pdg.lbl.gov/).

[12] M. Gronau and D. London, Phys. Lett. **B253** 483 (1991);
M. Gronau and D. Wyler, Phys. Lett. **B265** 172 (1991);
I. Dunietz, Phys. Lett. **B270** 75 (1991).

[13] G. Ecker and W. Grimus, Nucl. Phys. **B258** 328 (1985);
H. Nishiura, E. Takasugi and M. Tanaka, Prog. Theor. Phys. **84** 116 (1990), Prog.Theor.Phys.**84** 502 (1990), Prog.Theor.Phys.**85** 343 (1991).

[14] A. Datta, E.A. Paschos, J.-M.Schwartz and M.N.Sinha Roy, hep-ph/9509420 (1995), DO-TH 95/12.

[15] L. Wolfenstein, Phys. Rev. Lett. **51** 1945 (1983).

[16] T.E. Browder and K. Honscheid, UH 511-816-95, OHSTPY-HEP-E-95-010 (1995).

[17] T. Kurimoto and A. Tomita, in preparation.